

# Extra! Extra! Read All About the Universe!

Barb Mattson, PhD (USRA/NASA/GSFC)

Sara Mitchell (Syneren/NASA/GSFC)

Teaching and Learning 2014

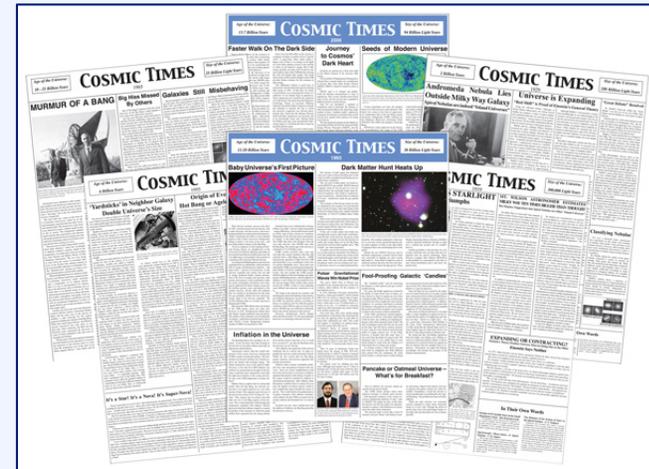
March 14, 2014 (Happy Pi Day!)

# Outline

- What is Cosmic Times?
- A taste of Cosmic Times
  - 1955 – Big Bang versus Steady State
  - 1965 – Breaking the Stalemate
  - 1993 – Cosmology's End?
  - 2006 – Continuing Story
- Tools for tailoring Cosmic Times to your classroom

# What is Cosmic Times? '

- Suite of curriculum support materials tracing our understanding of the expanding universe
- ' Includes:
  - 6 posters resembling front page newspapers 1919 to 2006 '
  - 3 newsletter versions of ' each poster, two at differentiated reading levels '
  - 4-5 lesson plans for each poster exploring fundamental science, social ' context, and reading skills '



You will receive the Cosmic Times posters and a DVD containing materials at the end of this workshop



# Quick notes on 1919

- The universe was believed to be:
  - 300,000 light years (size of Milky Way)
  - Static
  - Timeless
- Einstein's General Theory of Relativity (1916) revolutionized scientists' view of gravity
- Observations of the 1919 total solar eclipse supported Einstein's theory

Fundamental science concepts: motions of the Earth, Moon & Sun, solar eclipse, gravity, curved space-time

**Age of the Universe:** Infinite

# COSMIC TIMES

**Size of the Universe:** 300,000 Light Years

1919

## SUN'S GRAVITY BENDS STARLIGHT

### Einstein's Theory Triumphs

...The of the general... the greatest... of achievement in the history of human thought... was first proposed in the 1930s by astronomers who discovered that the amount of visible matter known... other than to... the amount of visible matter known...



...The Sun and the stars in the photographed... Prof. Eddington himself decided to lead an expedition to the island of Principe, in the Gulf of Guinea... the end of the path of totality... the Sun and the stars in the photographed... Prof. Eddington himself decided to lead an expedition to the island of Principe, in the Gulf of Guinea... the end of the path of totality... the Sun and the stars in the photographed... Prof. Eddington himself decided to lead an expedition to the island of Principe, in the Gulf of Guinea... the end of the path of totality...

### Expanding Or Contracting?

Einstein's Theory Triumphs Must Be Doing One Or the Other

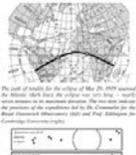
Einstein Says Neither

In 1917, after Einstein and the Dutch astronomer Willem de Sitter showed that Einstein's general theory of relativity could describe a highly simplified universe... Einstein's theory would predict that either all the stars would be expanding or moving away from one another, or that a gigantic explosion... Einstein's theory would predict that either all the stars would be expanding or moving away from one another, or that a gigantic explosion...

### In Their Own Words

Period of 25 Variable Stars in the Small Magellanic Cloud - Miss Harlowe Fenton

The Relation of the System of Stars to the Spiral Nebulae - G. P. Páduás



# Quick notes on 1929

- Edwin Hubble discovers:
  - Milky Way is but one of many galaxies
  - Universe is expanding

Age of the Universe:  
2 Billion Years
COSMIC TIMES
Size of the Universe:  
280 Million Light Years

1929

### Andromeda Nebula Lies Outside Milky Way Galaxy

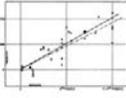
Spiral Nebulae are indeed "Island Universes"



Edwin Hubble found that the Andromeda nebula is an entire galaxy far beyond the Milky Way.

### Universe is Expanding

"Red Shift" is Proof of Einstein's General Theory



Hubble's discovery that the farther a galaxy is from Earth, the faster it is moving away from us, proved that the universe is expanding.

### "Great Debate" Resolved

Hubble's discovery with the "Great Debate" was the size of our own Milky Way Galaxy and the distance to, and nature of, spiral nebulae.

#### The Minds Atop Mount Wilson

The year 1929 was a landmark year for astronomy. It was the year that Edwin Hubble announced that the universe is expanding and that the Andromeda Nebula is an island universe far beyond the Milky Way.

Fundamental science concepts: redshift, distance to galaxies, Cepheid variables (patterns in data)

# 1955 – Origin of the Universe

- Scientists debate: is the universe:
  - ageless and infinite?
  - finite, with hot “bang” beginning?

**Age of the Universe:**  
6 Billion Years

## COSMIC TIMES

1955

**Size of the Universe:**  
4 Billion Light Years

**'Yardsticks' in Neighbor Galaxy Double Universe's Size**

The distance to the nearest galaxy is being re-measured by a team of astronomers led by Walter Baade, who has just announced that the distance to the nearest galaxy is 100,000 light years greater than previously estimated. Baade's discovery has come from study of the stars in the Magellanic Clouds, two small galaxies near the Milky Way, which are the nearest to our galaxy. Baade's discovery has come from study of the stars in the Magellanic Clouds, two small galaxies near the Milky Way, which are the nearest to our galaxy. Baade's discovery has come from study of the stars in the Magellanic Clouds, two small galaxies near the Milky Way, which are the nearest to our galaxy.

**Origin of Everything: Hot Bang or Ageless Universe?**

It will not be long before the origin of the universe will be the subject of a heated debate. The two main theories are the "hot bang" theory, which holds that the universe began with a hot, dense state, and the "ageless universe" theory, which holds that the universe has always existed in its present state. The debate is being heated by the discovery of the cosmic microwave background radiation, which is thought to be the remnant of the hot bang.

**Death of a Genius**

Albert Einstein is dead. The world has just lost its greatest scientific mind. Einstein died at the age of 76, after a long illness. His death is a great loss to the world. Einstein's theory of relativity has revolutionized our understanding of the universe. His discovery of the photoelectric effect earned him the Nobel Prize. His theory of general relativity predicted the existence of black holes and the expansion of the universe.

**Hoyle Scoffs at "Big Bang" Universe Theory**

British cosmologist Fred Hoyle has scoffed at the "big bang" theory of the origin of the universe. He believes that the universe has always existed in its present state. He is a proponent of the "steady state" theory, which holds that the universe is in a constant state of expansion and contraction. Hoyle's theory is in direct opposition to the "big bang" theory, which was proposed by George Gamow and others.

**Radio 'Ear' on the Universe Being Built**

The M.I.T. radio telescope has been built. It is the largest radio telescope ever built. It will be used to study the universe. The telescope is located in the state of New Mexico. It consists of a large dish antenna and a receiver. The telescope is being used to study the universe. It will be used to study the universe. It will be used to study the universe.

Gala...  
Recent attempt  
up a bit short, TV  
NGC 3521 and  
80 billion and 12  
puzzle is why the  
galaxies doesn't  
matter.  
Baby Un

EXPA  
Einstein's  
1917. Albert Einstein and the Dutch astronomer Willem  
theory of relativity could describe a black  
it when it was annu

Einstein Says Neither  
...ing One or the Other

The further we look into the cosmos...  
puzzled we are...  
physicists now wrestling  
...known  
...Later researchers proposed  
logical constant represents an  
...energy

# Reading Strategies

Use one of the reading strategies to understand the CT article “Origin of Everything”

# Reading Strategy: ' Reciprocal Teaching '

- ' Pair up
- ' Both partners read the same paragraph (aloud or to yourselves)
- ' One partner summarizes the paragraph for the other
- ' The other partner “checks and perfects” – state what you agree with, question parts you don't understand, add more information, connect ideas
- ' Read the next paragraph and switch roles
- ' Continue with each paragraph until you've read and understood the article

## Origin of Everything: Hot Bang or Ageless Universe?

**H**as the Universe always existed, or does it have a beginning, middle and an end? It's difficult to imagine a deeper mystery than this. However, this topic was recently discussed at the meeting of the National Academy of Sciences in Pasadena, California.

The case for an ageless, steady-state Universe was presented at the conference by astrophysicist Jesse L. Greenstein and physicist William A. Fowler of the California Institute of Technology. The steady-state theory says the Universe forever looks much like it does today; this "steady state" theory competes with the "evolutionary" theory of the

Universe. The evolutionary theory claims an initial collection of hot particles exploded at the dawn of time. These particles formed all the Universe's hydrogen (and perhaps helium) in one gigantic event.

Both theories explain – in entirely different ways – the fact that the Universe is expanding. This expansion was first detected in 1914, when American astronomer Vesto Melvin Slipher surveyed some galaxies and noticed the light from all of them was "red-shifted." All light travels in waves. In the spectrum of visible light, red light has the longest wavelength. If an object (such as a galaxy) is giving off light and the object is moving

away, that motion lengthens the wavelengths, causing the light to "red-shift." It's similar to how the sound of a retreating locomotive drops in pitch as it passes by you.

In the steady-state theory the expansion comes from the continuous bubbling up of the element hydrogen, from empty space at a rate of one particle every cubic meter every 300,000 years or so. This hydrogen eventually gathers and condenses into stars. Through nuclear fusions in their cores, stars make all the heavier elements (e.g. carbon, oxygen, silicon, iron, copper, etc.) from this hydrogen. As stars

*"Origin" continued on bottom of page 4*

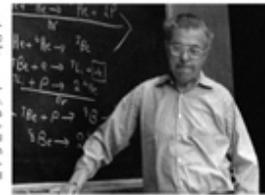
## Hoyle Scoffs at "Big Bang" Universe Theory

**B**ritish cosmologist Fred Hoyle has thrown down the gauntlet with regards to where and when all the Universe's elements were created. In a recent radio broadcast he criticized a competing theory, presented by Ukrainian-born American physicist George Gamow. He labeled Gamow's theory as a ridiculous "big bang."

Gamow's Evolutionary Theory of the Universe claims an initial stew of super-hot nuclear fusions of basic particles created all the hydrogen in the Universe in an explosive moment. The same blast caused space to expand. The ongoing expansion from that "big bang" is observed by astronomers today throughout cosmos.

Hoyle strongly disagrees with this theory. "It is an irrational process that cannot be described in scientific terms ... [not] challenged by an appeal to observation," he has written regarding Gamow's theory.

For one thing, the "big bang" requires something before the explosion. No one knows what that might be. If on the other hand, the Universe is eternal and stars are always being made and forever making heavier elements, as Hoyle suggests, there is no need for an initial explosion. Recent advances in nuclear physics seem to back Hoyle's "steady state" view, calling on the pressures and temperatures inside stars to manufacture all the heavy elements seen in the cosmos today. \*



Fred Hoyle

3

4

*"Origin" continued from page 3*

age, die, and explode, they scatter the heavier elements around the galaxies. These heavier elements mix with hydrogen, and new stars form with rocky planets around them – like our own Solar System. As evidence of that process, Greenstein and Fowler referred to the heavy-element-making red giant stars which can be seen today in our own galaxy.

An important point of the steady-state Universe is that it does change over time. Hoyle, the scientist who supports this theory, compares the deathless steady-state Universe to a river. It may appear unchanging, but there is plenty of movement and change under the surface. So, to borrow the old river saying, you can never step into the same Universe twice.

In contrast, there is the "evolutionary" theory of Russian-born American physicist George Gamow and his colleagues Ralph Alpher and Robert Herman. These scientists say the explosion and radioactive decay of a hot ball of neutrons at the birth of the Universe created all hydrogen and some helium. These elements formed as the blast expanded and cooled. The first stars were made of only this original hydrogen and helium. Those stars fused those original elements into new, heavier elements.

These heavier elements were then scattered through the galaxies as the first stars died, and this led to the more complex mixtures of elements seen in stars now.

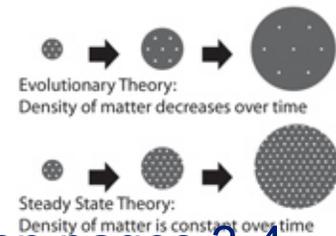
This evolutionary theory also explains why galaxies are moving away from each other: they are all still in flight from the power of the initial blast. Newton's laws of motion help to explain this (an object in motion will remain in motion unless a force acts on it). There may be other direct evidence of

the blast as well. Alpher and Herman have predicted that some faint left-over heat from that initial explosion may still exist in the form of stretched-out light waves called "microwaves" just a few degrees above absolute zero. However, no one has yet figured out a way to detect these left-over microwaves.

More evidence for the evolutionary Universe comes from Edwin Hubble's 1929 measurements of the speed of galaxies beyond our own. Hubble found that the farther away a galaxy is, the faster it appears to be moving away. This is exactly what would be expected if there was an ancient blast that started it all, and things have been moving away ever since.

The downside to an evolutionary Universe, of course, is that it doesn't end happily. There's no unlimited supply of hydrogen in the steady-state theory. In the evolutionary Universe, the Universe might expand forever and will eventually run out of hydrogen; the stars eventually burn out, and the Universe cools down to a vast frozen graveyard of dead stars. Another possibility for the evolutionary Universe is that the gravity of all matter might eventually pull everything back together again in a gigantic collapse that rebounds, explodes, and starts the Universe all over – this is the endlessly exploding and collapsing Universe described by the late physicist Richard Tolman from CalTech.

Which theory is correct? Only more research with bigger and better telescopes will tell. \*



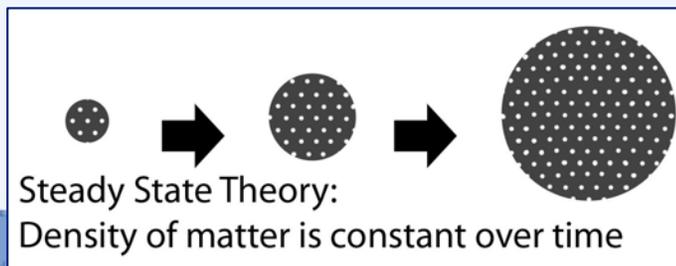
*Illustration of the matter-density history of the Universe according to the evolutionary theory (top) and the steady state theory (bottom).*

“Origin of Everything” article on pages 3-4  
Do Paragraphs 2, 4, 5, 6, 7

# Summarize the Article '

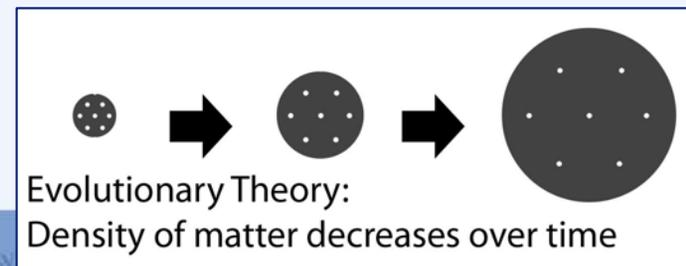
## Steady State Universe

- ' Unchanging situations need not be static
- ' New matter can be created spontaneously as the universe expands (a few hundred atoms per year per galaxy)
- ' The universe is constant in its overall density



## Evolutionary Universe

- ' Universe is expanding from a state of high density and pressure.
- ' Hydrogen & Helium were formed as universe cooled.
- ' There should be left over a background radiation with a temperature of  $\sim 5$  Kelvin
- ' Hoyle scoffed at this theory and coined the term "Big Bang"



# The Evidence is Clear

## Bowl of Evidence

Scientists sort through theories by examining evidence and making inferences

# Steady State vs. Big Bang '

- Resolution of Steady State vs Big Bang won't come until the mid-to-late 1960s
- But as a competing theory, the Steady State provides the impetus to make observations to test the theories
- Note that this lesson can be adapted for **any** science topic where there are two (or more) competing theories

# 1955 – Origin of the Universe

- Scientists debate: is the universe:
  - ageless and infinite?
  - finite, with hot “bang” beginning?
- Both theories account for observations
- Deadlock!

Fundamental science concepts: nature of science, origin of the universe

**Age of the Universe: 6 Billion Years**      **COSMIC TIMES**      **Size of the Universe: 4 Billion Light Years**

1955

### 'Yardsticks' in Neighbor Galaxy Double Universe's Size

The universe is twice as large as previously thought, according to a study by astronomers Walter Baade and Fritz Zwicky, published in the journal *Astronomical Journal* in 1955. Baade's discovery came from simply measuring stars in terms of their absolute magnitude. He found that the stars in the Magellanic Clouds were brighter than those in our own galaxy, which meant that the distance to the Magellanic Clouds was smaller than previously thought. This discovery led to the realization that the universe is much larger than previously estimated.

### Origin of Everything: Hot Bang or Ageless Universe?

It's still unclear as to whether the universe had a beginning, and whether it is finite or infinite. The debate is between those who believe in a "hot bang" and those who believe in an ageless universe. The "hot bang" theory suggests that the universe began with a massive explosion, while the ageless universe theory suggests that the universe has always existed and is expanding.

### Death of a Genius

Albert Einstein's death in 1955 is a significant event in the history of science. His theory of relativity revolutionized our understanding of space and time, and his work continues to influence modern physics.

### Hoyle Scoffs at "Big Bang" Universe Theory

British cosmologist Fred Hoyle has scoffed at the "big bang" theory of the origin of the universe. He believes in a steady state model, where the universe has always existed and is expanding. He argues that the "big bang" theory is based on flawed assumptions and that there is no evidence to support it.

### Radio 'Ear' on the Universe Being Built

The Murchison Radio-astronomy Observatory (MRO) is a large radio telescope facility in Australia. It is used to study the universe in the radio spectrum, and has been instrumental in the discovery of pulsars and other celestial objects.

### It's a Star! It's a Nova! It's Super-Nova!

There is a wide range of stellar phenomena, from ordinary stars to supernovae. Supernovae are the explosive deaths of stars, and they can be seen from billions of light years away. They are important for understanding the evolution of the universe and the formation of new stars.

### Hoyle Scoffs at "Big Bang" Universe Theory

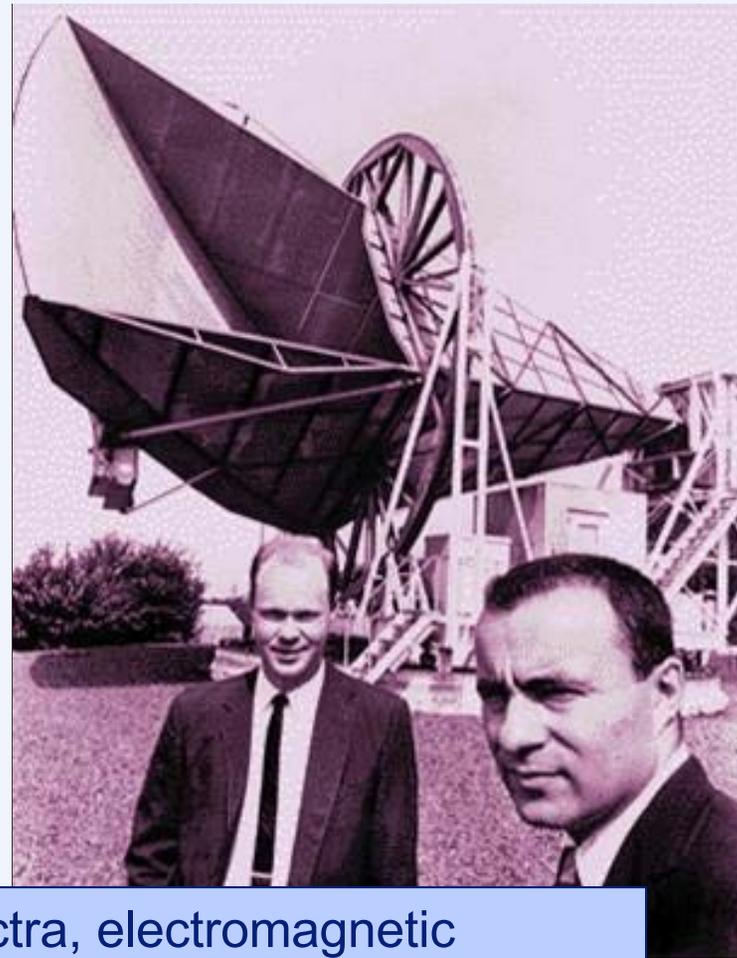
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# 1965 - Breaking the Stalemate

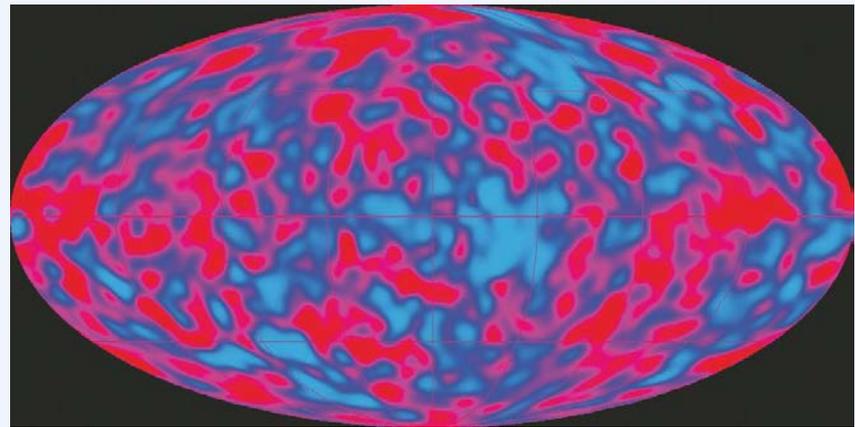
- A hot “bang” should leave left-over heat
- Data and theory came together in 1965
  - Penzias and Wilson found a 3 K residual noise while making radio observations of the Milky Way
  - Peebles and Dicke (Princeton) had just calculated an estimate for the temperature of the residual background in the microwave region



Fundamental science concepts: spectra, electromagnetic spectrum, origin of the Universe

# 1993 - Cosmology's End? '

- By the mid-90s, cosmologists thought that they had only to “fill in the details”



- Remaining questions:
  - Will the expansion continue forever, or will universe eventually collapse back on itself?
  - What is the mass-density of the universe (which would answer the above)?

# Brief diversion ...

- Things may not be what they seem
- When we see odd behavior, we look ' more carefully at what's going on '

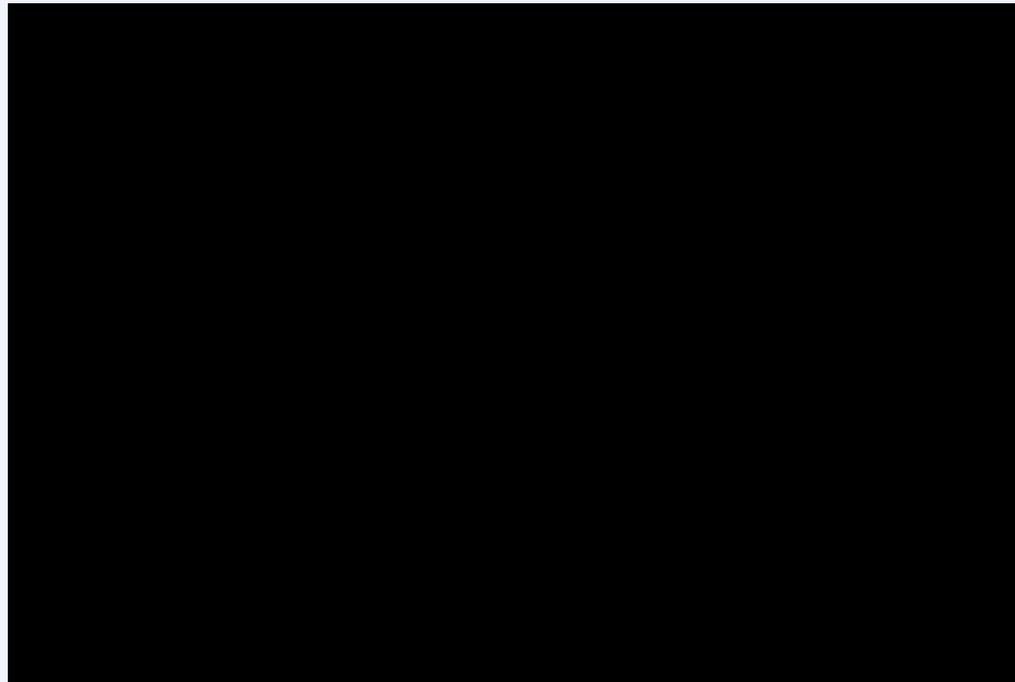
# Not the End of Cosmology ' In 1997... '

- ' Gravity is the longest-reaching force according to physics
- ' So, the expansion of the universe should be slowing down...
- ' By observing supernovae in distant galaxies, researchers determine that the expansion is **speeding up** '



Cosmologists get **very** excited!

# History of the Universe's Expansion



Video clip from DVD *Beyond the Solar System: Expanding the Universe in the Classroom*, produced for NASA by the Harvard-Smithsonian Center for Astrophysics. © Smithsonian Institution

# 2006 – Cosmologists are busy

- Dark energy is well-established, having been detected in many ways
- Still, the nature of dark energy is largely a mystery
- Stay tuned to this continuing science story...

Fundamental science concepts: expanding universe, distances in the universe, supernovae, gravity

**Age of the Universe:**  
13.7 Billion Years

## COSMIC TIMES

2006

**Size of the Universe:**  
94 Billion Light Years

### Faster Walk On The Dark Side

There is thick evidence for the existence of dark energy, a peculiar energy that is boosting the expansion of the cosmos. Dark energy accounts for approximately 73 percent of the universe. It appears to be accelerating the distance between galaxies and working against gravity, but its nature is still unknown.

The new evidence is the discovery of an effect dark energy has on photons of light from the earliest universe. This recent light began moving across the universe just 380,000 years after the Big Bang, and its initial energy has been shifted into the microwave part of the energy spectrum in the 13 billion years since.

This additional evidence is good news to cosmologists who had estimated a general effect of dark energy in 1998. At that time, this estimate of its nature was based on the expansion of a cluster of very distant Type Ia supernovae. These supernovae are treated by the expansion of a white dwarf. The team from the University of California at Berkeley, led by Lawrence Berkeley National Lab and the High Energy Astrophysics Research Center, led by David Spergel, had intended to measure the rate at which the supernova's expansion was slowing down. Instead, they found that the distance between each supernova was growing, and at an increasingly faster rate. Seeing about five billion years ago, some cosmologists had energy began to overtake the force of gravity and push galaxies apart.

The researchers chose to trace if dark energy and to be combined with dark matter, which together confounding problem in astronomy.

As for the dark energy, it's dark energy's glow is gone. While there are at least a half dozen theories, some seem very odd at an observational stage.

### Journey to Cosmos' Dark Heart

Scientists are gearing up to shed some light on the darkest mystery in the universe: dark energy.

NASA's Alpha Centauri Department of Energy has selected three concept studies for consideration to become their first Dark Energy Mission (DEM). DEM is slated to launch as early as 2011.

DEM's goal is to observe and double-check the distance measurements to Type Ia supernovae. This is to help avoid critical gaps to help fast the universe has expanded at different points in cosmic history.

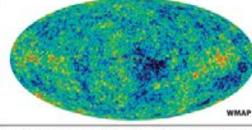
Type Ia's are considered a standard or comparison yardstick to determine the distance to other astronomical objects. By observing a large number of these "standard candles" of supernovae in galaxies far and near, cosmologists have been able to plot how quickly these galaxies are flying away from us.

The three proposed concept studies are: SuperNova Acceleration Probe (SNAP), the Advanced Dark Energy Physics Telescope (ADEPT), and the Dark Energy Space Telescope (DESI). Each would look at the supernovae in a different way.

SNAP would use a 1.5-meter optical-infrared telescope with a CCD charge-coupled device light detector that is free of optical artifacts, with a billion pixels. SNAP's detector has an area of about 1.5 square meters. It would be able to see about 10,000 Type Ia supernovae in each year over a wide range of distances—about 100 times more supernovae than are now detected.

ADEPT would use a 1.5-meter near-infrared telescope to track 10,000 galaxies and 1,000 Type Ia supernovae over two years. It would avoid an additional year of observing, to detect 1,000 square degrees of sky. This would gather new findings on changes in the large-scale distribution of matter in the cosmos over the Big Bang. Both phases of DESI's variations would improve on the sensitivity of similar ground-based observations by a factor of about 10.

### Seeds of Modern Universe



A 3-D map of the temperature fluctuations in the Cosmic Microwave Background as measured by the Wilkinson Microwave Anisotropy Probe. The data is color-coded by temperature, with red representing warmer and blue representing cooler. The fluctuations are the seeds of the universe's structure.

Cosmic researchers now have the sharpest view ever of the universe's early structure. This better view comes in the form of super-precise temperature data of the sky-filling cosmic microwave background (CMB) collected by the Wilkinson Microwave Anisotropy Probe (WMAP). The CMB is the afterglow of the Big Bang.

WMAP has early success on the cosmic background radiation, the last remnant of the Big Bang. It's the earliest light that's been seen since the first few seconds after the Big Bang. That's why the universe pulled in like a hyperspherical lump of bread dough. It's that moment of what cosmologists call inflation which allowed for any fluctuations in the original Big Bang to manifest now. But subtle differences in temperature exist in the CMB. And these differences, in turn, are now thought to be the seeds of today's galaxy clusters and galaxies.

Researchers have been comparing and contrasting the new WMAP data with a range of other cosmic measurements—light travels of stars, galaxy clustering, hydrogen gas clouds, superclusters, and others. In contrast to a new understanding of the universe's past, present and future.

### Biggest Mystery: What is Dark Energy?

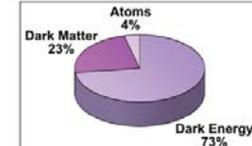
The farther we look into the universe, the more puzzled we are. That's the expansion of the universe and the mysterious force that is pushing galaxies apart and making the entire universe expand at an increasing rate. In the 1990s, observations of distant supernovae in the 1990s showed us this startling discovery.

Initially, there was one big hint that dark energy existed from before measurements found evidence of it. None other than the great Albert Einstein had theorized an "anti-gravity" effect, which he called the "cosmological constant." Scientists today are looking much more about dark energy's impact on the universe to see if it can connect an expanding fabric factor, without any connection to the real universe.

Einstein's intuition predicted that the statistical content represents an underlying background energy. This energy might create some kind of pressure on the cosmos. Unfortunately, the theory predicts that the energy might be a 120 orders of magnitude stronger than dark energy appears to be.

Another strong candidate for dark energy is something called quintessence. The word is the same as the ancient Greek term for a mysterious fifth element—beyond earth, air, fire and water—which existed in the theory of the time. The cosmological constant, the modern theory of quintessence holds that it is some kind of energy field that pushes particles apart. It is not clear if the theory is testable, which is why scientists think dark energy has only been in the discovery stage for the last 100 years, or so, in effect it's a new way for 20th-century physics.

Scientists would like to learn much more about dark energy's impact on the universe to see if it can connect an expanding fabric factor, without any connection to the real universe.



WMAP also reveals that the universe is composed of 73 percent dark energy, 23 percent dark matter, and 4 percent atoms. The energy density of dark matter is expected to be the greatest in the universe's future.

### 'First Light' Wins Nobel



The 2006 Nobel Prize in Physics was awarded to three scientists for their discovery of the cosmic microwave background (CMB) radiation from the beginning of the universe as we see it today.

According to the Nobel Prize website, "These three scientists also marked the beginning of modern cosmology as a physical science."

Using data from the satellite-based Cosmic Background Explorer (COBE), a team led by Arthur M. Lee and George Smoot, Jr. discovered that the universe has been expanding since the Big Bang. They also found that it matched predictions from the Big Bang theory perfectly. They also found that the universe's expansion is accelerating, a discovery that was difficult to account for the present structure of the universe, say cosmologists. Later experiments also marked the beginning of modern cosmology as a physical science.

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### Sorting Out The Dark Stuff

Dark matter is the universe's "missing mass." It does not appear to interact with normal matter, other than to tug on it with gravity. Dark matter was first proposed in the 1930s by astronomer Fritz Zwicky, who discovered that it matched predictions from the Big Bang theory perfectly. They also found that the universe's expansion is accelerating, a discovery that was difficult to account for the present structure of the universe, say cosmologists. Later experiments also marked the beginning of modern cosmology as a physical science.

There's some good news and bad news about the cosmos. The bad news is that the normal matter, which makes up humans, the Earth and Sun, is only about 5 percent of the universe. The good news is that the dark matter is made of something that we can't see. It's not clear if the theory is testable, which is why scientists think dark energy has only been in the discovery stage for the last 100 years, or so, in effect it's a new way for 20th-century physics.

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### Adopt SNAP, DESI

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Type Ia's are considered a standard or comparison yardstick to determine the distance to other astronomical objects. By observing a large number of these "standard candles" of supernovae in galaxies far and near, cosmologists have been able to plot how quickly these galaxies are flying away from us.

The three proposed concept studies are: SuperNova Acceleration Probe (SNAP), the Advanced Dark Energy Physics Telescope (ADEPT), and the Dark Energy Space Telescope (DESI). Each would look at the supernovae in a different way.

SNAP would use a 1.5-meter optical-infrared telescope with a CCD charge-coupled device light detector that is free of optical artifacts, with a billion pixels. SNAP's detector has an area of about 1.5 square meters. It would be able to see about 10,000 Type Ia supernovae in each year over a wide range of distances—about 100 times more supernovae than are now detected.

ADEPT would use a 1.5-meter near-infrared telescope to track 10,000 galaxies and 1,000 Type Ia supernovae over two years. It would avoid an additional year of observing, to detect 1,000 square degrees of sky. This would gather new findings on changes in the large-scale distribution of matter in the cosmos over the Big Bang. Both phases of DESI's variations would improve on the sensitivity of similar ground-based observations by a factor of about 10.

### Sorting Out The Dark Stuff

Dark matter is the universe's "missing mass." It does not appear to interact with normal matter, other than to tug on it with gravity. Dark matter was first proposed in the 1930s by astronomer Fritz Zwicky, who discovered that it matched predictions from the Big Bang theory perfectly. They also found that the universe's expansion is accelerating, a discovery that was difficult to account for the present structure of the universe, say cosmologists. Later experiments also marked the beginning of modern cosmology as a physical science.

Using data from the satellite-based Cosmic Background Explorer (COBE), a team led by Arthur M. Lee and George Smoot, Jr. discovered that the universe has been expanding since the Big Bang. They also found that it matched predictions from the Big Bang theory perfectly. They also found that the universe's expansion is accelerating, a discovery that was difficult to account for the present structure of the universe, say cosmologists. Later experiments also marked the beginning of modern cosmology as a physical science.

There's some good news and bad news about the cosmos. The bad news is that the normal matter, which makes up humans, the Earth and Sun, is only about 5 percent of the universe. The good news is that the dark matter is made of something that we can't see. It's not clear if the theory is testable, which is why scientists think dark energy has only been in the discovery stage for the last 100 years, or so, in effect it's a new way for 20th-century physics.

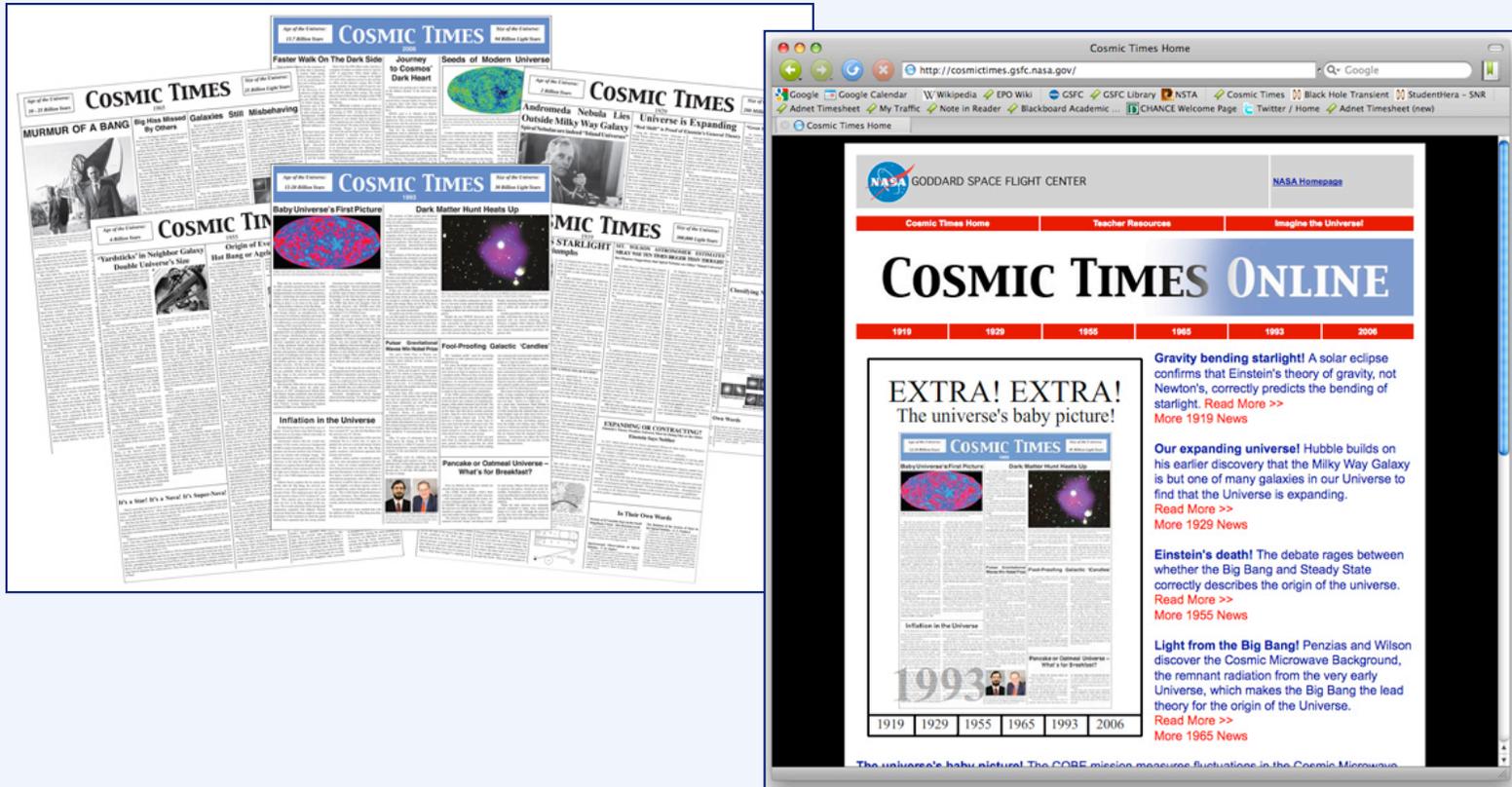
Scientists would like to learn much more about dark energy's impact on the universe to see if it can connect an expanding fabric factor, without any connection to the real universe.

# It is now 2014...

- What is our view of the universe? '
  - Finite
  - Changing
  - 13.7 billion years old

# Cosmic Times'

Posters, Newsletters, Teacher's Resources, Lessons & Online-Edition all on our website: <http://cosmictimes.gsfc.nasa.gov/>



# Classroom Resources: 'A Brief Tour'

- A variety of tools are available to help you navigate Cosmic Times and find the right resources for your classroom

The screenshot shows the Cosmic Times Online website interface. At the top, there is a navigation bar with the NASA logo and 'GODDARD SPACE FLIGHT CENTER'. Below this, a red navigation bar contains 'Cosmic Times Home' and 'Teacher Resources'. The main content area features a large 'COSMIC TIMES ONLINE' title and a timeline of years: 1919, 1929, 1955, 1965, 1993, and 2006. A blue callout box with a white arrow points to the 'Teacher Resources' link in the navigation bar. The main content area displays several news items with headlines and 'Read More >>' links. At the bottom, there is a footer with contact information and a note about the website's origin.

Teacher Resources

**EXTRA! EXTRA!**  
Light from the Big Bang!

**Gravity bending starlight!** A solar eclipse confirms that Einstein's theory of gravity, not Newton's, correctly predicts the bending of starlight. [Read More >>](#)  
[More 1919 News](#)

**Our expanding universe!** Hubble builds on his earlier discovery that the Milky Way Galaxy is but one of many galaxies in our Universe to find that the Universe is expanding. [Read More >>](#)  
[More 1929 News](#)

**Einstein's death!** The debate rages between whether the Big Bang and Steady State correctly describes the origin of the universe. [Read More >>](#)  
[More 1955 News](#)

**Light from the Big Bang!** Penzias and Wilson discover the Cosmic Microwave Background, the remnant radiation from the very early Universe, which makes the Big Bang the lead theory for the origin of the Universe. [Read More >>](#)  
[More 1965 News](#)

**The universe's baby picture!** The COBE mission measures fluctuations in the Cosmic Microwave Background, which explain where structure in our Universe comes from and confirming the role of inflation in the early universe. [Read More >>](#)  
[More 1993 News](#)

**Dark energy!** The supernova distance scale leads to the discovery of dark energy, a puzzling new component of our Universe that had been undetected until 1997, and its nature remains a mystery in 2006. [Read More >>](#)  
[More 2006 News](#)

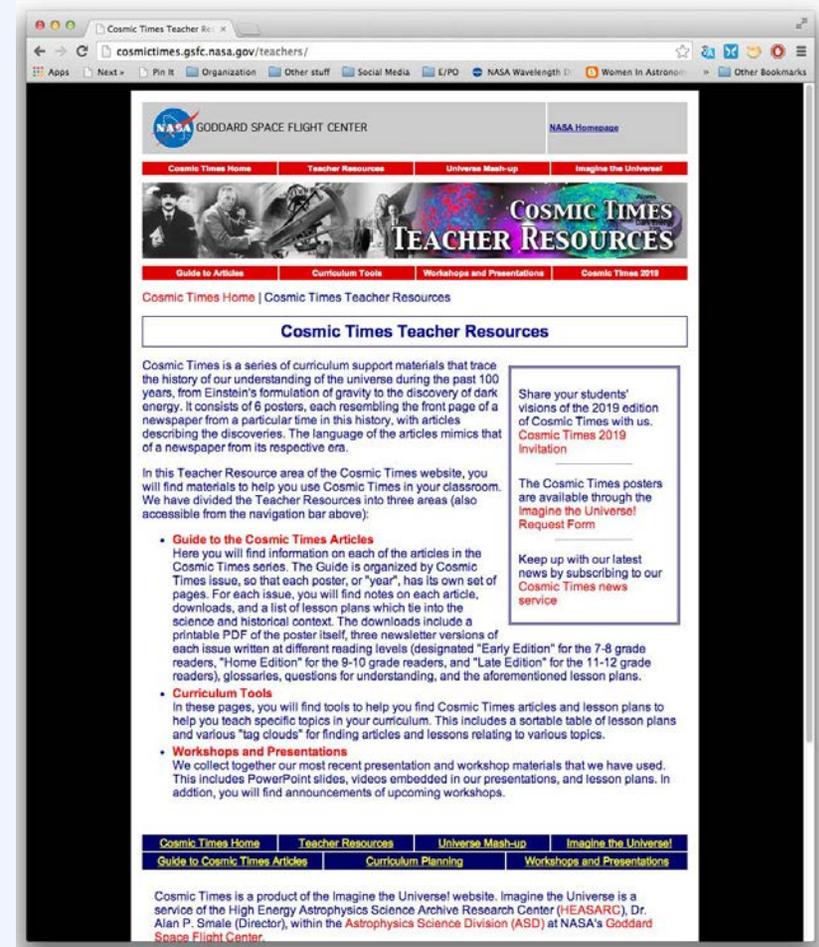
[Cosmic Times Home](#) [Teacher Resources](#) [Universe Mash-up](#) [Imagine the Universe!](#)

1919 1929 1955 1965 1993 2006

Cosmic Times is a product of the Imagine the Universe! website. Imagine the Universe is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), Dr. Alan P. Smale (Director), within the Astrophysics Science Division (ASD) at NASA's Goddard Space Flight Center.

# Classroom Resources: 'A Brief Tour'

- A variety of tools are available to help you navigate Cosmic Times and find the right resources for your classroom



The screenshot shows the Cosmic Times Teacher Resources website. The page features a navigation bar with links for 'Cosmic Times Home', 'Teacher Resources', 'Universe Mash-up', and 'Imagine the Universe!'. Below the navigation bar is a large banner for 'COSMIC TIMES TEACHER RESOURCES'. The main content area is titled 'Cosmic Times Teacher Resources' and contains a detailed introduction to the series, a list of resources, and a sidebar with a 'Share your students' visions' section. The resources listed include:

- Guide to the Cosmic Times Articles**: Information on each article, organized by issue, with notes, downloads, and lesson plans.
- Curriculum Tools**: Tools to find articles and lesson plans for specific topics, including a sortable table of lesson plans and 'tag clouds'.
- Workshops and Presentations**: Recent presentation and workshop materials, including PowerPoint slides, videos, and lesson plans.

The sidebar includes a 'Share your students' visions of the 2019 edition of Cosmic Times with us. Cosmic Times 2019 Invitation' section and a 'Keep up with our latest news by subscribing to our Cosmic Times news service' section.

# Classroom Resources: ' Guide to the Articles '

The screenshot shows the Cosmic Times Teacher Resources page on the NASA Goddard Space Flight Center website. The page features a navigation bar with links for 'Cosmic Times Home', 'Teacher Resources', 'Universe Mash-up', and 'Imagine the Universe!'. Below the navigation bar is a banner for 'COSMIC TIMES TEACHER RESOURCES' with sub-links for 'Guide to Articles', 'Curriculum Tools', 'Workshops and Presentations', and 'Cosmic Times 2019'. The main content area is titled 'Cosmic Times Teacher Resources' and contains an introductory paragraph about the series, a list of resources, and a footer with contact information. A blue arrow points from the right side of the page to the 'Guide to the Articles' link in the list.

**Cosmic Times Teacher Resources**

Cosmic Times is a series of curriculum support materials that trace the history of our understanding of the universe during the past 100 years, from Einstein's formulation of gravity to the discovery of dark energy. It consists of 6 posters, each resembling the front page of a newspaper from a particular time in this history, with articles describing the discoveries. The language of the articles mimics that of a newspaper from its respective era.

In this Teacher Resource area of the Cosmic Times website, you will find materials to help you use Cosmic Times in your classroom. We have divided the Teacher Resources into three areas (all accessible from the navigation bar above):

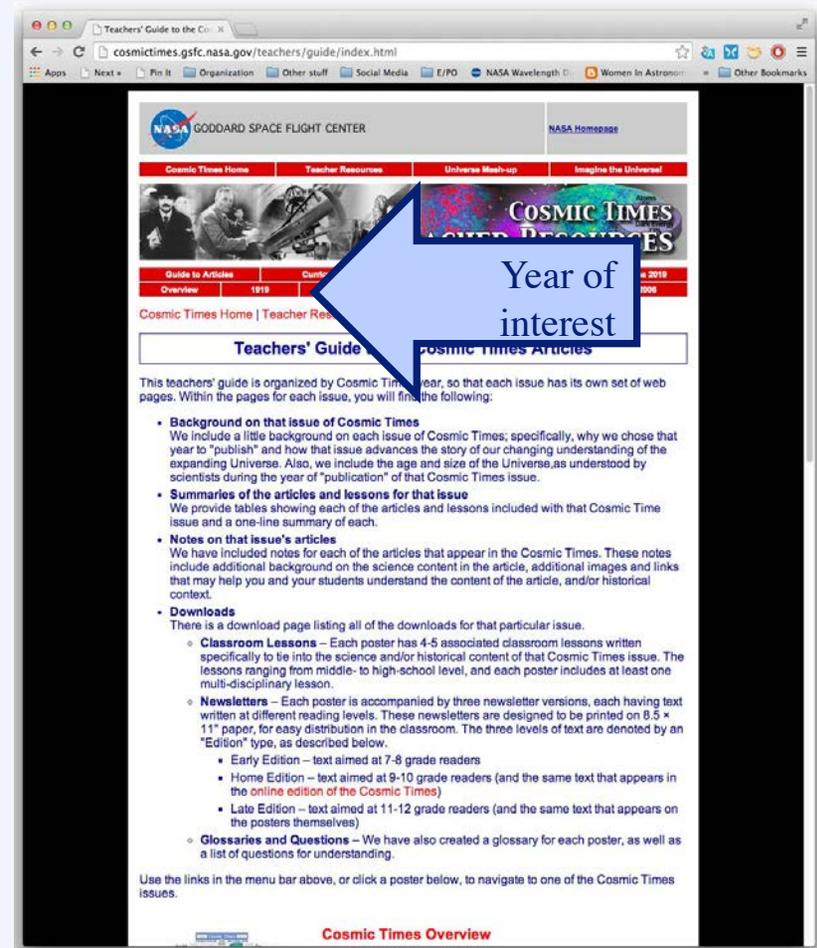
- **Guide to the Cosmic Times Articles**  
Here you will find information on each of the Cosmic Times series. The Guide is organized by Cosmic Times issue, so that each poster, or "year", has its own page. For each issue, you will find notes on each poster, downloadable PDFs, and a list of lesson plans which tie into the science and historical context. The downloads include a printable PDF of the poster itself, three newsletter versions of each issue written at different reading levels (designated "Early Edition" for the 7-8 grade readers, "Home Edition" for the 9-10 grade readers, and "Late Edition" for the 11-12 grade readers), glossaries, questions for understanding, and the aforementioned lesson plans.
- **Curriculum Tools**  
In these pages, you will find tools to help you find Cosmic Times articles and lesson plans to help you teach specific topics in your curriculum. This includes a sortable table of lesson plans and various "tag clouds" for finding articles and lessons relating to various topics.
- **Workshops and Presentations**  
We collect together our most recent presentation and workshop materials that we have used. This includes PowerPoint slides, videos embedded in our presentations, and lesson plans. In addition, you will find announcements of upcoming workshops.

**Guide to the Articles**

Cosmic Times is a product of the Imagine the Universe! website. Imagine the Universe! is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), Dr. Alan P. Smale (Director), within the Astrophysics Science Division (ASD) at NASA's Goddard Space Flight Center.

# Classroom Resources: ' Guide to the Articles '

- ' Here you will find further information organized by year/issue of Cosmic Times



The screenshot shows the NASA Cosmic Times Teachers' Guide website. The page is titled "Teachers' Guide to the Cosmic Times" and is organized by year/issue. A blue arrow points to a "Year of interest" dropdown menu. The page content includes a "Background on that issue of Cosmic Times" section, "Summaries of the articles and lessons for that issue", "Notes on that issue's articles", and "Downloads" section. The "Downloads" section lists "Classroom Lessons", "Newsletters", and "Glossaries and Questions".

**Teachers' Guide to the Cosmic Times**

This teachers' guide is organized by Cosmic Times year, so that each issue has its own set of web pages. Within the pages for each issue, you will find the following:

- **Background on that issue of Cosmic Times**  
We include a little background on each issue of Cosmic Times; specifically, why we chose that year to "publish" and how that issue advances the story of our changing understanding of the expanding Universe. Also, we include the age and size of the Universe, as understood by scientists during the year of "publication" of that Cosmic Times issue.
- **Summaries of the articles and lessons for that issue**  
We provide tables showing each of the articles and lessons included with that Cosmic Time issue and a one-line summary of each.
- **Notes on that issue's articles**  
We have included notes for each of the articles that appear in the Cosmic Times. These notes include additional background on the science content in the article, additional images and links that may help you and your students understand the content of the article, and/or historical context.
- **Downloads**  
There is a download page listing all of the downloads for that particular issue.
  - **Classroom Lessons** – Each poster has 4-5 associated classroom lessons written specifically to tie into the science and/or historical content of that Cosmic Times issue. The lessons range from middle- to high-school level, and each poster includes at least one multi-disciplinary lesson.
  - **Newsletters** – Each poster is accompanied by three newsletter versions, each having text written at different reading levels. These newsletters are designed to be printed on 8.5 × 11" paper, for easy distribution in the classroom. The three levels of text are denoted by an "Edition" type, as described below.
    - **Early Edition** – text aimed at 7-8 grade readers
    - **Home Edition** – text aimed at 9-10 grade readers (and the same text that appears in the [online edition of the Cosmic Times](#))
    - **Late Edition** – text aimed at 11-12 grade readers (and the same text that appears on the posters themselves)
  - **Glossaries and Questions** – We have also created a glossary for each poster, as well as a list of questions for understanding.

Use the links in the menu bar above, or click a poster below, to navigate to one of the Cosmic Times issues.

[Cosmic Times Overview](#)

# Classroom Resources: ' Guide to the Articles '

- ' Here you will find further information organized by year/issue of Cosmic Times

- Downloads

- Poster
- Newsletters
- Glossary
- Questions for understanding

- Additional information ' about each article '

- Classroom lesson plans

**1919 Cosmic Times**

This poster is the first edition of the Cosmic Times, with the publication date chosen to coincide with the announcement of the first test of Einstein's General Theory of Relativity. Einstein published the theory in 1915, but the first test supporting General Relativity was announced in 1919. In fact, it was this test of General Relativity that really propelled Einstein to "rock star" status.

- Download 1919 poster, newsletters, and glossary
- Teacher's Guide to the 1919 articles
- 1919 Lessons

Order your set of Cosmic Times posters through the [Imagine the Universe! Request Form](#)

**1919 Article Overview**

Age of Universe: Infinite  
Size of Universe: 300,000 Light Years

Article	Thread	Summary
Sun's Gravity Bends Starlight	Expanding Universe	Observations of stars near the Sun during the eclipse of 1919 show that the starlight bends just as predicted by General Relativity.
Sidebar: Why a Total Eclipse?	--	Describes why observers needed a solar eclipse to make observations of starlight bending around the Sun.
Mount Wilson Astronomer Estimates Milky Way Ten Times Bigger Than Thought	Size of the Universe	Astronomer Harlow Shapely finds that the Milky Way is 10 times bigger than previous measurements, using the period-luminosity relationship for Cepheid variables as discovered by Henrietta Leavitt.
Expanding or Contracting?	Expanding Universe	Einstein's theory of General Relativity predicts that the Universe cannot be static – it must be expanding or contracting. Einstein adds the "Cosmological Constant" to keep the Universe static.
In Their Own Words	--	Snippets of papers published by other astronomers during this time. The snippets highlight the Cepheid period-luminosity relationship, redshift of galaxies, and the nature of spiral nebulae.

# Classroom Resources: ' Curriculum Tools '

The screenshot shows the Cosmic Times Teacher Resources website. The page features a navigation bar with links for 'Cosmic Times Home', 'Teacher Resources', 'Universe Mash-up', and 'Imagine the Universe!'. Below the navigation bar is a banner for 'COSMIC TIMES TEACHER RESOURCES' with sub-links for 'Guide to Articles', 'Curriculum Tools', 'Workshops and Presentations', and 'Cosmic Times 2019'. The main content area is titled 'Cosmic Times Teacher Resources' and includes a description of the Cosmic Times series, a list of resources, and a 'Share your students' visions' section. A blue arrow points to the 'Curriculum Tools' link in the navigation bar.

**Cosmic Times Teacher Resources**

Cosmic Times is a series of curriculum support materials that trace the history of our understanding of the universe during the past 100 years, from Einstein's formulation of gravity to the discovery of dark energy. It consists of 6 posters, each resembling the front page of a newspaper from a particular time in this history, with articles describing the discoveries. The language of the articles mimics that of a newspaper from its respective era.

In this Teacher Resource area of the Cosmic Times website, you will find materials to help you use Cosmic Times in your classroom. We have divided the Teacher Resources into three areas (also accessible from the navigation bar above):

- Guide to the Cosmic Times Articles**  
Here you will find information on each of the articles in the Cosmic Times series. The Guide is organized by Cosmic Times issue, so that each poster, or "year", has its own set of pages. For each issue, you will find notes for each article, downloads, and a list of lesson plans which tie into the science and historical context. The downloads include a printable PDF of the poster itself, the download links for each issue written at different reading levels (middle school readers, "Home Edition" for the general public, and high school readers), glossaries, questionnaires, and more.
- Curriculum Tools**  
In these pages, you will find lesson plans, activities, and various "tag clouds" for each issue.
- Workshops and Presentations**  
We collect together our most recent workshops and presentation materials that we have used. This includes PowerPoint slides, videos, and other materials embedded in our presentations, and lesson plans. In addition, you will find announcements of upcoming workshops.

Share your students' visions of the 2019 edition of Cosmic Times with us. [Cosmic Times 2019 Invitation](#)

The Cosmic Times posters are available through the [Imagine the Universe! Request Form](#)

Keep up with our latest news by subscribing to our [Cosmic Times news service](#)

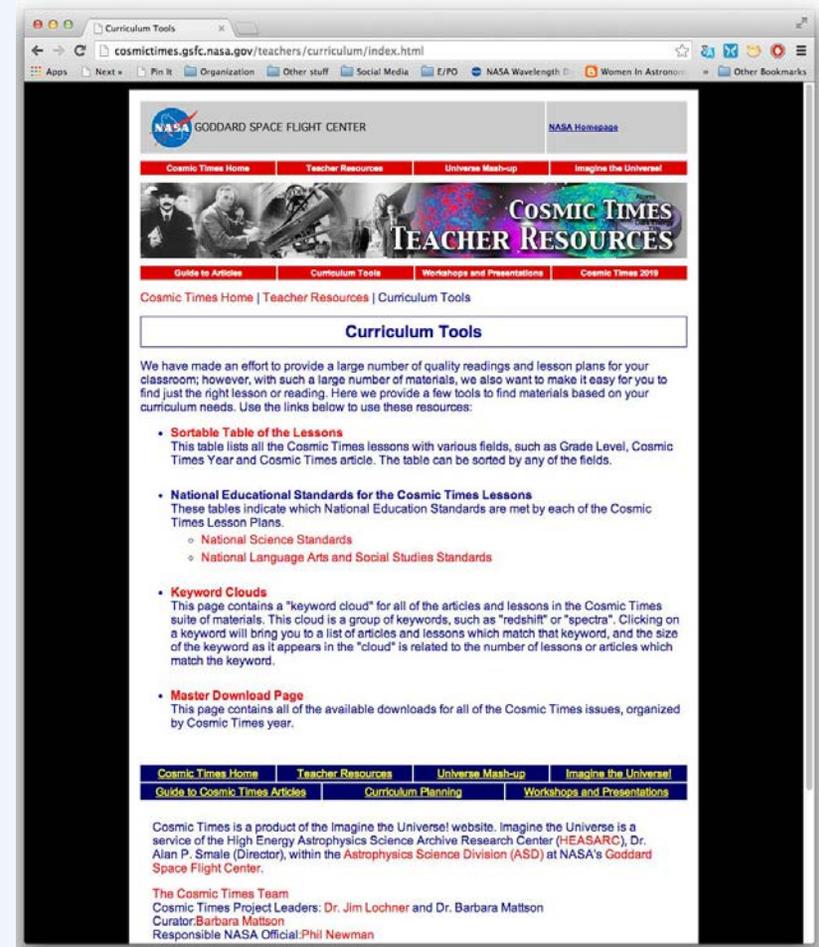
**Curriculum Tools**

[Cosmic Times Home](#) | [Teacher Resources](#) | [Universe Mash-up](#) | [Imagine the Universe!](#)  
[Guide to Cosmic Times Articles](#) | [Curriculum Planning](#) | [Workshops and Presentations](#)

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# Classroom Resources: ' Curriculum Tools '

- ' Here you will find tools to help you find the right lessons and articles for your curriculum needs



The screenshot shows a web browser window displaying the 'Curriculum Tools' page from the Cosmic Times Teacher Resources website. The page is titled 'Curriculum Tools' and is part of the 'Cosmic Times Home | Teacher Resources | Curriculum Tools' section. The main content area lists several resources:

- Sortable Table of the Lessons**: This table lists all the Cosmic Times lessons with various fields, such as Grade Level, Cosmic Times Year and Cosmic Times article. The table can be sorted by any of the fields.
- National Educational Standards for the Cosmic Times Lessons**: These tables indicate which National Education Standards are met by each of the Cosmic Times Lesson Plans.
  - National Science Standards
  - National Language Arts and Social Studies Standards
- Keyword Clouds**: This page contains a "keyword cloud" for all of the articles and lessons in the Cosmic Times suite of materials. This cloud is a group of keywords, such as "redshift" or "spectra". Clicking on a keyword will bring you to a list of articles and lessons which match that keyword, and the size of the keyword as it appears in the "cloud" is related to the number of lessons or articles which match the keyword.
- Master Download Page**: This page contains all of the available downloads for all of the Cosmic Times issues, organized by Cosmic Times year.

At the bottom of the page, there is a footer section with the following text:

Cosmic Times is a product of the Imagine the Universe! website. Imagine the Universe is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), Dr. Alan P. Smale (Director), within the Astrophysics Science Division (ASD) at NASA's Goddard Space Flight Center.

The Cosmic Times Team  
Cosmic Times Project Leaders: Dr. Jim Lochner and Dr. Barbara Mattson  
Curator: Barbara Mattson  
Responsible NASA Official: Phil Newman

# Classroom Resources: ' Curriculum Tools '

- ' Here you will find tools to help you find the right lessons and articles for your curriculum needs
  - Sortable list of lessons

The screenshot shows a web browser displaying the 'Cosmic Times Lesson Plans' page. The page features a navigation bar with links to 'Cosmic Times Home', 'Teacher Resources', 'Universe Mash-up', and 'Imagine the Universe'. Below the navigation bar is a banner for 'COSMIC TIMES TEACHER RESOURCES' with sub-links for 'Guide to Articles', 'Curriculum Tools', 'Workshops and Presentations', and 'Cosmic Times 2017'. The main content area is titled 'Cosmic Times Lesson Plans' and includes a table listing various lessons with columns for Year, Lesson Title, Summary, Level, Article, and Discipline.

Year	Lesson Title	Summary	Level	Article	Discipline
All/Any	<a href="#">Cosmic Times Jigsaw</a>	Students work in teams to see the big picture of about how scientists have come to know what they do about the Universe using articles from the Cosmic Times posters.	MS,HS	All	Multidisciplinary
All/Any	<a href="#">Cosmic Times Gallery Walk</a>	Students spend a few minutes at each Cosmic Times poster to answer an open-ended question about the information on that poster.	MS,HS	All	Multidisciplinary
2006	<a href="#">Tools of the Trade</a>	Students explore the telescopes and technologies that will shape our understanding of the Universe in the coming years.	HS	Journey to Cosmos' Dark Heart	Physics, Astronomy
2006	<a href="#">Century Timeline</a>	Students create a timeline of world events from 1905 through 2006, the years encompassed by the Cosmic Times posters, to get a sense of the history surrounding the discoveries over the past century.	MS,HS	All	Multidisciplinary
2006	<a href="#">Things Are Not What They Seem</a>	Students explore a discrepant event by designing experiments to test what makes a "come back can" return or UV beads change color.	MS,HS	Sorting Out the Dark Stuff	Physics, Astronomy
2006	<a href="#">Measuring Dark Energy</a>	Students simulate an experiment in which the discovery of dark energy can be made by plotting modern supernova distances on a Hubble Diagram.	HS	Faster Walk on the Dark Side	Physics, Astronomy

# Classroom Resources: ' Curriculum Tools '

- ' Here you will find tools to help you find the right lessons and articles for your curriculum needs
  - Sortable list of lessons
  - National Education Standards for each lesson

The screenshot shows the 'Cosmic Times Teacher Resources' page. It features a navigation menu with 'Cosmic Times Home', 'Teacher Resources', 'Universe Mash-up', and 'Imagine the Universe!'. Below the navigation is a banner for 'COSMIC TIMES TEACHER RESOURCES' with sub-links for 'Guide to Articles', 'Curriculum Tools', 'Workshops and Presentations', and 'Cosmic Times 2019'. The main content area is titled 'Cosmic Times Lesson Plans National Science Educational Standards'. It includes a table showing the alignment of lesson plans with National Science Education Standards (NS-5-8.1 through NS-9-12.7). The table has columns for 'National Science Standards for Grades 5-8' and 'National Science Standards for Grades 9-12'. The rows list lesson plans: 'Erisson and His Times', 'Eclipses and Moon Phases', 'Two Versions of Gravity: Newton and Erisson', and 'Erisson's Gravity'.

	National Science Standards for Grades 5-8					National Science Standards for Grades 9-12				
	NS-5-8.1	NS-5-8.2	NS-5-8.4	NS-5-8.5	NS-5-8.7	NS-9-12.1	NS-9-12.2	NS-9-12.4	NS-9-12.5	NS-9-12.7
Erisson and His Times										
Eclipses and Moon Phases	X		X							
Two Versions of Gravity: Newton and Erisson						X	X	X		X
Erisson's Gravity						X	X	X		X

# Classroom Resources: ' Curriculum Tools '

- ' Here you will find tools to help you find the right lessons and articles for your curriculum needs

- Sortable list of lessons
- National Education Standards for each lesson
- Keyword clouds

The screenshot shows a web browser window displaying the Cosmic Times Keyword Clouds page. The page features a NASA logo and navigation tabs for 'Cosmic Times Home', 'Teacher Resources', 'Universe Mash-up', and 'Imagine the Universe'. Below the navigation is a 'Cosmic Times Keyword Cloud' section. A callout box points to the 'big bang' keyword in the cloud, and another callout box points to a list of related articles and lessons.

**Click a keyword**

**See related articles and lessons**

**ceheid variable stars**

**Articles**

- 1919 In Their Own Words: (1919 Cosmic Times Issue)
  - Online article
  - Teacher Background
- Andromeda Nebula Lies Outside Milky Way Galaxy: (1929 Cosmic Times Issue)
  - Online article
  - Teacher Background
- 'Yardsticks' in Neighbor Galaxy Double Universe's Size: (1955 Cosmic Times Issue)
  - Online article
  - Teacher Background

**Lessons**

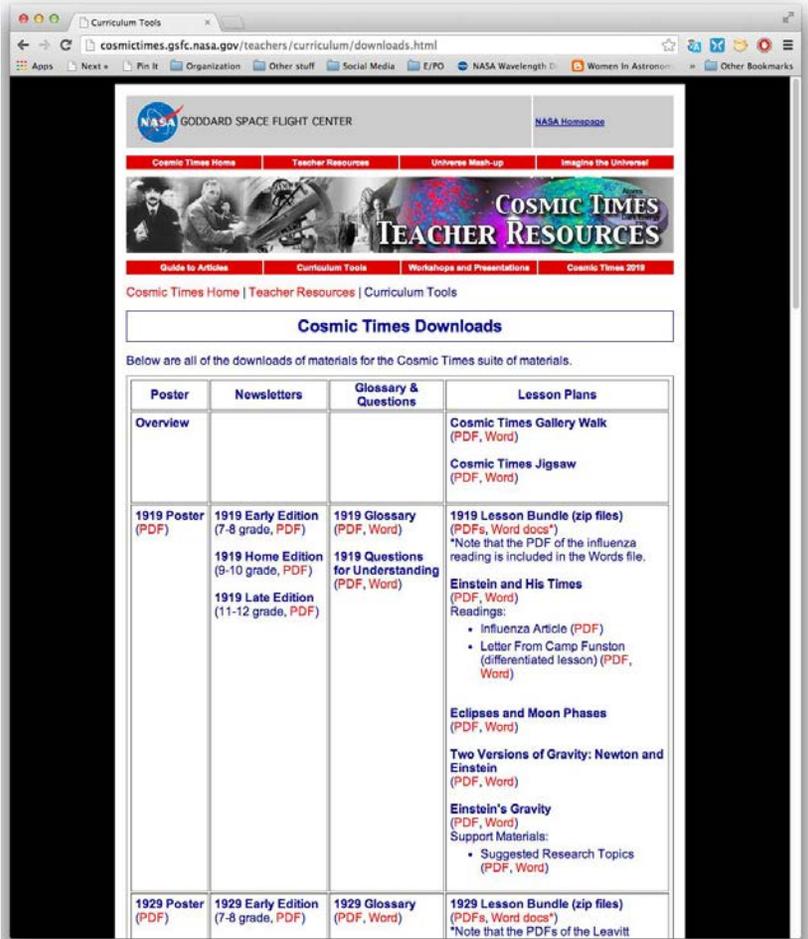
- Discovering the Milky Way (1929 Cosmic Times Issue)
- Just How Far is that Star? (1929 Cosmic Times Issue)
- Cosmic Jeopardy (1955 Cosmic Times Issue)
- Discovering 'Yardsticks' are 'Metersticks' (1955 Cosmic Times Issue)

\* Back to the top

# Classroom Resources: ' Curriculum Tools '

- ' Here you will find tools to help you find the right lessons and articles for your curriculum needs

- Sortable list of lessons
- National Education Standards for each lesson
- Keyword clouds
- Master download page



The screenshot shows a web browser displaying the Cosmic Times Teacher Resources page. The page features a navigation bar with links to Cosmic Times Home, Teacher Resources, Universe Mash-up, and Imagine the Universe!. Below the navigation bar is a header for 'COSMIC TIMES TEACHER RESOURCES' with sub-links for Guide to Articles, Curriculum Tools, Workshops and Presentations, and Cosmic Times 2019. The main content area is titled 'Cosmic Times Downloads' and contains a table of materials for download.

Poster	Newsletters	Glossary & Questions	Lesson Plans
<b>Overview</b>			<b>Cosmic Times Gallery Walk</b> (PDF, Word) <b>Cosmic Times Jigsaw</b> (PDF, Word)
<b>1919 Poster</b> (PDF)	<b>1919 Early Edition</b> (7-8 grade, PDF) <b>1919 Home Edition</b> (9-10 grade, PDF) <b>1919 Late Edition</b> (11-12 grade, PDF)	<b>1919 Glossary</b> (PDF, Word) <b>1919 Questions for Understanding</b> (PDF, Word)	<b>1919 Lesson Bundle (zip files)</b> (PDFs, Word docs) *Note that the PDF of the influenza reading is included in the Words file. <b>Einstein and His Times</b> (PDF, Word) Readings: <ul style="list-style-type: none"><li>• <b>Influenza Article</b> (PDF)</li><li>• <b>Letter From Camp Funston</b> (differentiated lesson) (PDF, Word)</li></ul> <b>Eclipses and Moon Phases</b> (PDF, Word) <b>Two Versions of Gravity: Newton and Einstein</b> (PDF, Word) <b>Einstein's Gravity</b> (PDF, Word) Support Materials: <ul style="list-style-type: none"><li>• <b>Suggested Research Topics</b> (PDF, Word)</li></ul>
<b>1929 Poster</b> (PDF)	<b>1929 Early Edition</b> (7-8 grade, PDF)	<b>1929 Glossary</b> (PDF, Word)	<b>1929 Lesson Bundle (zip files)</b> (PDFs, Word docs) *Note that the PDFs of the Leavitt

# 2019 Cosmic Times '

- ' In the capstone lesson plan, students are asked to look to the future
- ' Students speculate what we will know on the 100<sup>th</sup> anniversary of the Cosmic Times, what technology we will have, and what questions are still unanswered
- ' We're inviting submissions for a possible "student gallery" of 2019 Cosmic Times creations
- ' See the website for more

The screenshot shows the NASA Cosmic Times 2019 Teacher Resources website. At the top, there is a NASA logo and the text "GODDARD SPACE FLIGHT CENTER" and "NASA Homepage". Below this is a navigation bar with three red buttons: "Cosmic Times Home", "Online Edition", and "Imagine the Universe". The main content area features a large banner with the text "COSMIC TIMES 2019" and "TEACHER RESOURCES" over a background image of scientists and a telescope. Below the banner is another navigation bar with four red buttons: "Guide to Articles", "Curriculum Tools", "Workshops and Presentations", and "Cosmic Times 2019". The main text area contains the following information:

**Cosmic Times 2019**

**Share your students' visions of the 2019 issue of Cosmic Times with us!**

Do your students have a version of the 2019 issue of Cosmic Times? How much closer will we be to solving the mysteries of dark energy and the nature of the universe? What tools will we have then that we don't have now?

We want to know what your students envision for the next steps in understanding the nature of our universe. After all, they are the next generation of scientists and engineers who will be working on these questions. We will chose a few of the best submissions to share in a Student Gallery.

**What you need to do**

1. Do the [Cosmic Times 2019 lesson plan](#) with your class (Download the file: [doc](#), [pdf](#)).
2. Send us the following:
  - **Your class creation(s)** These can take the form of print materials (like an "old fashioned" newspaper or a newsletter), web pages, audio podcasts, or videos – it is up to you and your class to decide what form the news will take in 2019.For video or audio submissions, we would also like a copy of the transcript.

Email the file or link to your students' creation to: [Barbara Mattson](#)

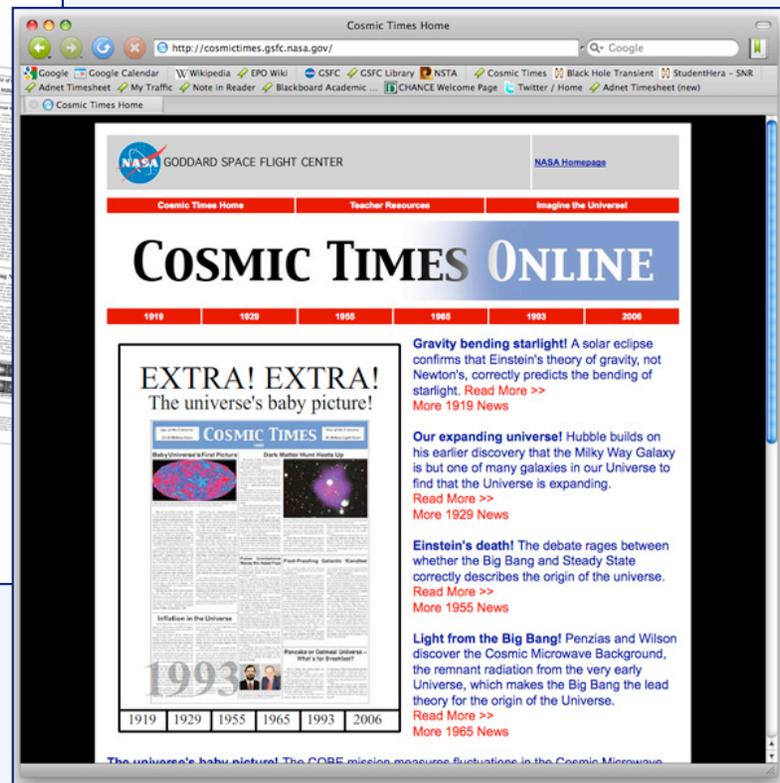
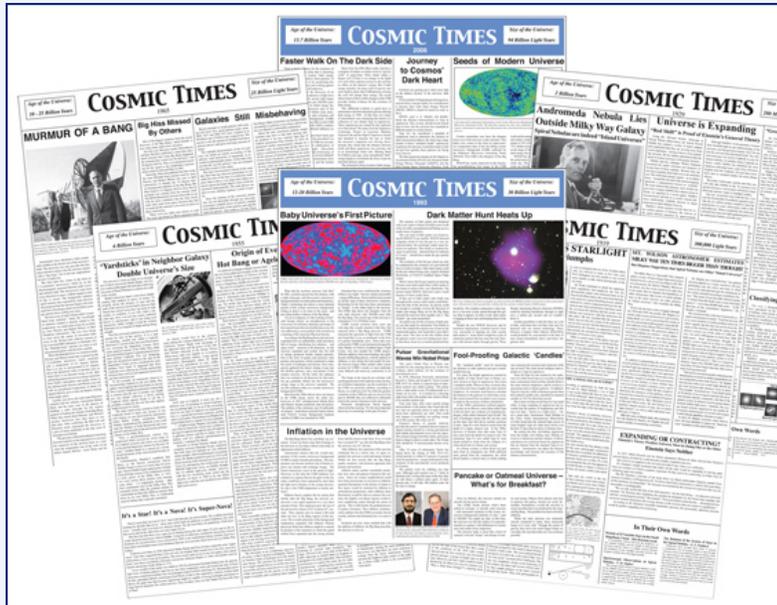
- **Release forms** In order to consider your students' contribution(s), we need signed releases from every student who worked on the project. You can send them either by email or postal mail. If you have scanned versions of the signed forms, just email them to the address above. If you want to send physical copies, request our address when you make your email submissions.

Release form: [PDF](#), [doc](#)

3. Other considerations:
  - **Privacy disclosures**

# Cosmic Times'

Posters, Newsletters, Teacher's Resources, Lessons & Online-Edition all on our website: <http://cosmictimes.gsfc.nasa.gov/>

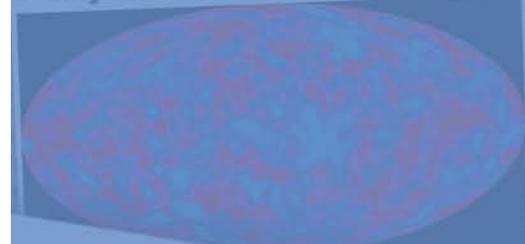


# MURMUR OF A BANG

# Andromeda Nebula Lies Outside Milky Way Galaxy

Spiral Nebulae are indeed "Island Universes"

# Baby Universe's First Picture



# EXPANDING OR CONTRACTING? Einstein's Theory Predicts Universe Must be Doing One or the Other

Einstein Says Neither

# SUN'S GRAVITY BENDS STARS Einstein's Theory Triumphs

perhaps the greatest history of... London, which...

# Radio 'Ear' on the Universe Being Built



# 'Yardsticks' in Neighbor Galaxy

The universe is twice as large as we thought... Baade's discovery hasn't come from simple...

# Double Universe's Size

# Dark Matter Hunt Heats Up

The mystery of dark matter just deepened with a new report of about 20 trillion suns-worth of invisible, unexplained stuff hiding out in a...



# Classifying Nebulae

For over a thousand years, astronomers dated on the nature and evolution of faint clouds of gas and dust in the universe. However, until recently, their insufficient observations...

# Biggest Mystery: What is Dark Energy?

The further we look into the cosmos, the puzzled we are. That's the experience of physicists now wrestling with an unknown...

# Century Timeline

Compare the Cosmic Times timeline with events in:

- \* Other Science
- \* Arts/Entertainment/Culture
- \* World History/Politics

Opportunities for cross-disciplinary collaboration

# Cosmic Times Timeline '

- ' 1912 - Henrietta Leavitt determines Cepheid Period-Luminosity relationship
- 1916 - Einstein's Theory of Gravity
- 1929 - Hubble's Law
- 1934 - "Super-nova" identified by Baade & Zwicky
- 1949 - Alpher & Gamow discuss nucleosynthesis
- 1952 - Baade recalibrates Cepheid P-L relationship
- 1965 - Penzias & Wilson discover CMB
- 1970 - Vera Rubin makes case for Dark Matter
- 1981 - Guth proposes Cosmic Inflation
- 1993 - COBE measures anisotropies in CMB
- 1998 - Dark Energy discovered
- 2003 - WMAP refines anisotropies in CMB